CHAPTER 8

CIRCUIT COMPONENTS

Most circuits contain three basic components. These are resistors, inductors and capacitors. Each has its own particular effect on the circuit current. This effect will depend on whether the circuit is supplied from an a.c. or d.c. source. A general description and the uses of each component will be discussed in this chapter, while an indepth study of each will be made in later chapters.

8.1 RESISTORS

Resistors are classified by the value of resistance, the power dissipation and the voltage they can withstand. They have a wide range of appearances, quality and the materials from which they are constructed. Because a resistor is regarded as a current limiting device, it is most frequently referred to by its resistance value.

(a) SMALL RESISTORS OF FIXED VALUE

(i) One of the earlier types of physically small resistor was made from carbon and non-conducting materials packed into an insulated container. Leads passing through the container into the carbon composition allow connections to be made to the resistor. Another method of producing the resistor was to compress the compound into a cylindrical shape and bake it so that it became a solid rod. The rod was then cut to the required size, leads attached and then covered with a ceramic compound. Many resistors of this type are still being used but modern physically small resistors are manufactured by covering a ceramic core with a film of conducting material such as carbon or metallic oxide.

The carbon film resistor is produced by heating the core to a high temperature in a heavily carbonised atmosphere. The carbon adheres to the core making a conducting skin around the core. This product is then placed in a machine which removes some of the carbon in such a way that a spiral track of carbon remains between the two ends of the core. (Figure 8.1).

Figure 8.1

Leads are attached to the ends and the whole resistor coated with a ceramic compound. The metal film resistor is produced by a similar method. Resistors of these types range from two ohms to twenty two megohms. They vary in size from approximately one millimeter in diameter up to about ten millimeters. Because of their small physical size they are used extensively in the electronic industry in such applications as calculators, computors, television sets, etc.

(ii) Tolerance

It is very expensive to manufacture a small resistor to exact specifications. To keep cost to a minimum mass produced resistors are rated at a certain value plus or minus a percentage error of that value. For example, a 47 ohm resistor may be graded 47 ohms plus or minus 10%. This means that the resistance value of the resistor will be between $47 \pm (47 \times \frac{10}{100})$ or between 42.3 Ω or 51.7 Ω . This degree of accuracy is acceptable to the electronic industry. Tolerances are usually limited to 5%, 10% or 20%. The amount of tolerance of a resistor is usually decided by the quality of its manufacture. Carbon compound resistors have large tolerances, but the tolerances of the different film resistances can be as low as 1%.

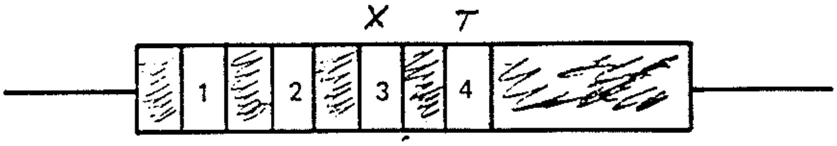
(iii) Colour coding of resistors

Most physically small resistors are cylindrical in structure. The circular surface presents problems in identifying the resistor by printing the relevant resistance and tolerance on such a surface. To overcome this the resistors are identified by colour bands (Figure 8.2).

Figure 8.2

There are up to four bands on a colour banded resistor. (Figure 8.3).

Figure 8.3



The first and second band give the numbers in the resistance value, the third band gives the multiplying values in powers of ten, while the fourth band gives the tolerance.

COLOUR	1st DIGIT	2nd DIGIT	MULTIPLIER	TOLERANCE
Black	0	0	x 1	
Brown	1	1	$\times 10^{1}$	
Red	2	2	$\times 10^{2}$	
Orange	3	3	$\times 10^{3}$	
Yellow	4	4	$\times 10^{4}$	
Green	5	5	$\times 10^{5}$	
Blue	6	6	$\times 10^{6}$	
Violet	7	7		
Grey	8	8		
White	9	9		
Gold			$\times 10^{-1}$	$\pm$ 5%
Silver			$\times 10^{-2}$	$\pm$ 10%

No fourth colour band indicates a tolerance of $\pm$ 20%.

PREFERRED VALUES OF RESISTANCE

It would be impossible economically to manufacture a resistor for each resistance value. Resistors are made to a preferred value, examples of which are shown in the following list.

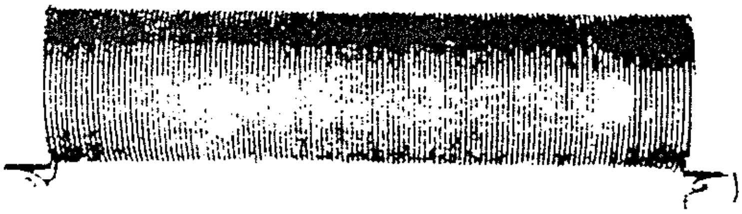
Resistors	Colour bands
10 ohm	brown black black
47 ohm	yellow violet black
100 ohm	brown black brown
220 ohm	red red brown
470 ohm	yellow violet brown
1,000 ohm	brown black red
1,500 ohm	brown green red
2,200 ohm	red red red
3,300 ohm	orange orange red
4,700 ohm	yellow violet red
10,000 ohm	brown black orange

15,000 ohm	brown green orange
22,000 ohm	red red orange
47,000 ohm	yellow violet orange
100,000 ohm	brown black yellow
220,000 ohm	red red yellow
470,000 ohm	yellow violet yellow

(b) WIRE WOUND RESISTORS

A resistor with a higher power dissipation than the film type resistor is the wire wound resistor. Examples of wire wound resistors are shown in figure 8.4.

Figure 8.4



The low power, wire wound resistors have the wire wound around a temperature resistant insulation material and are ceramic coated. The larger wire wound resistors have the resistor wire exposed so that the heat generated by the current is dissipated into the surrounding atmosphere. A typical range of wire wound resistors would be from one ohm to one megohm with a power dissipation up to 250W. Wire wound resistors are used in the electrical field where currents are in the magnitude of milliamperes or amperes, whereas film type resistors are confined to the microampere and to the milliampere range.

(c) GRID RESISTORS

Currents in the range of tens or hundreds of amperes are regulated by banks of resistor grids. A typical cast iron grid pattern is shown in figure 8.5.

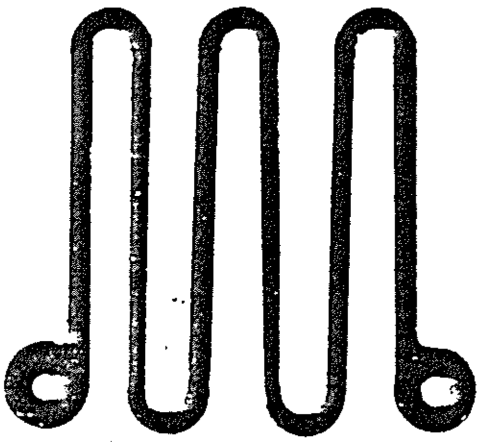
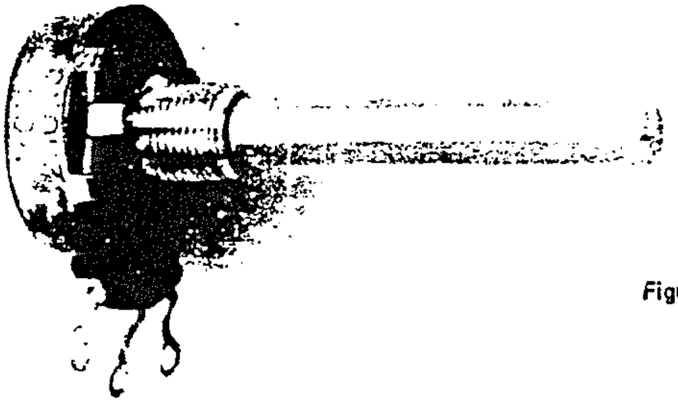


Figure 8.5

The grids are built into stacks so that adjacent grids are in series with each other. The stacks are exposed so that the heat generated by the high currents is quickly dissipated into the surrounding atmosphere. This type of resistor is used in large electric motor control.

(d) VARIABLE RESISTORS

There are two basic types of variable resistors, namely the potentiometer and the rheostat. A potentiometer has three terminals and is used to vary the potential difference from a fixed voltage source. (Figure 8.6).



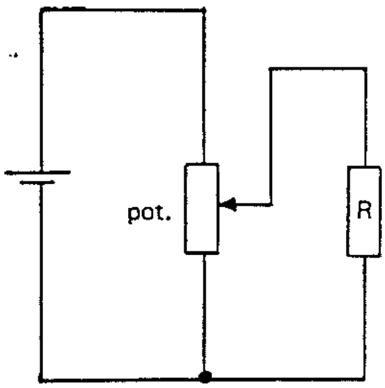
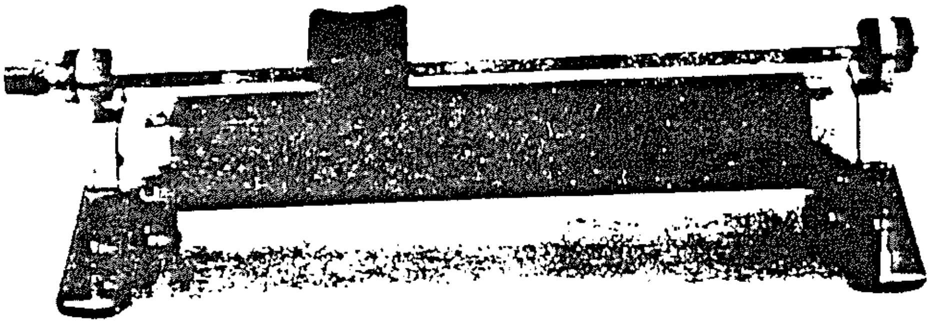


Figure 8.6

A rheostat, which is usually physically larger than a potentiometer is used as a current controlling device. (Figure 8.7).



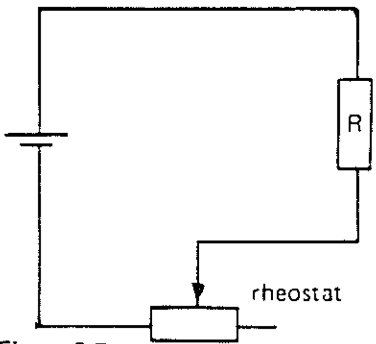


Figure 8.7

A rheostat is connected in series in a circuit whereas a potentiometer is connected in parallel with a source.

8.2 INDUCTORS

A component is said to have inductance if it has the ability to create a magnetic field. As magnetism is a direct result of electric current, almost all current carrying devices possess inductance to a certain degree. The unit of inductance is the henry (H). Inductors are made by forming a length of conducting material into a series of tightly packed turns. (Figure 8.8).

Figure 8.8

Passing current through the coil creates a concentrated magnetic field. The magnetic field does not appear instantly but takes time to build up. This is because of magnetic field is a form of energy, this energy being converted from electrical energy in the conductor. Inductors are used in d.c. circuits as a means of storing energy, the energy only being stored when current is flowing in the inductor.

8.3 CAPACITORS

When two metals are in close proximity and separated from each other by an insulated area, a capacity to store electric charge is created. A simple capacitor consists of two plates separated by a dielectric, the name given to the area between the plates. This dielectric may be air or other substances such as mica, oil or manufactured insulators (paraffin paper, plastics). A capacitor is described by the type of dielectric it contains. Typical capacitors of fixed values are shown in figure 8.9.

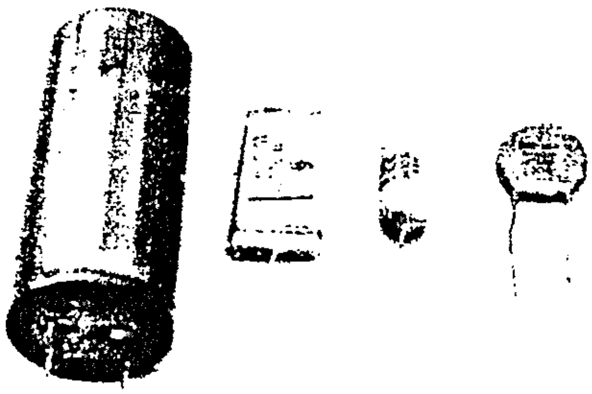


Figure 8.9

Variable capacitors are extensively used in the electronics industry. They are mostly air dielectric capacitors as shown in figure 8.10.

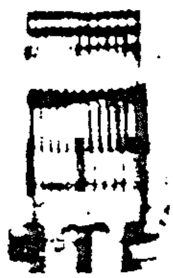


Figure 8.10

The importance of resistance, inductance and capacitance will be further explained in later chapters. It is the intention of the author at this stage merely to make the reader aware of the components that produce different reactions within a circuit.

TUTORIAL 1.8 (Revision)

(1) Calculate the time it would take for a constant current of 15 amperes to produce 4500 coulombs of electricity.

(2) Determine the power consumed by an electric iron that draws 5 amperes from a 240 volt supply.

(3) Calculate the time taken by a 5kW hoist motor to raise a 1000 kg load from ground level to a height of 100 metres.

(4) Convert -

(a) 2680 m A to A

(b) 0.268 k V to m V

(c) 3000 Ω to k Ω

(d) 250 m A to μA

(e) 0.2 M Ω to Ω

(f) 2864 μF to F

(g) 96 k Ω to M Ω

(h) 0.0025 A to μ A

(i) 10 V to k V

(j) 47 V to m V